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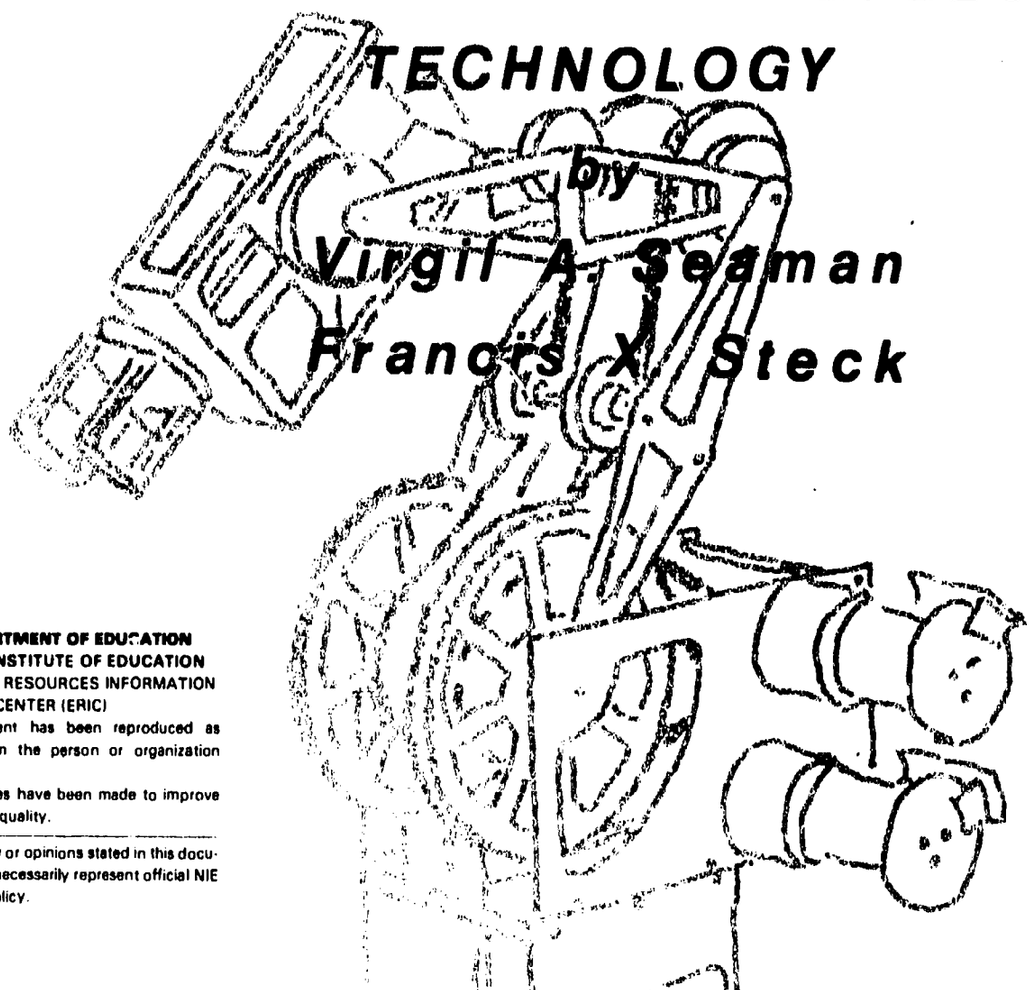
ABSTRACT

This document contains suggestions for integrating the elements of robotics into technology education courses from elementary through junior high and high school levels. Eighteen courses into which robotics instruction can be incorporated are listed. They include the following: exploring industry and technology, introduction to industrial and technological systems, communication systems, electronic communication systems, construction systems, electromechanical systems and servicing, construction planning and design, constructing and servicing structures and systems, manufacturing systems, manufacturing materials and processes, product and production system design, manufacturing production systems, transportation systems, technical elements of transportation, planning and designing transportation systems, human and product transporting systems, research and development, and entrepreneurship. For each course title, grade level and size of school are given; robotics learning activities are detailed in a step-by-step fashion. A brief bibliography is included in the guide. (KC)

ROBOTICS APPLICATIONS FOR THE CURRICULUM TO REFLECT TECHNOLOGY



by

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RATIONALE

As future technology education instructors, the authors of this document have tried to make themselves acquainted with the most recent trends in technology education. One of these is the Technical Foundation of America's "Industry & Technology Education: A Guide for Curriculum Designers, Implementors, and Teachers."

At the same time, the institution we attend, Indiana State University, has provided us with a unique opportunity to explore the expanding field of robotics. The combination of these two factors has led the authors to examine the potential role of robotics in technology education.

This document represents an effort to analyze and synthesize the elements of robotics into technology education. The document contains course titles at the various levels specified within the original "Industry & Technology Education" document. Under each of the course titles are suggestions for robotics applications which the authors feel are appropriate for technology education programs at all levels. The applications are suggestions only, meant to serve as a guide to the instructor and not meant to be a curriculum in robotics.

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ABOUT THE AUTHORS

Mr. Seaman and Mr. Steck are currently pursuing doctoral degrees in curriculum and instruction with a specialization in industrial arts at Indiana State University, Terre Haute, Indiana.

During the spring and summer of 1984, they collaborated with Dr. J. Larry Heath, professor of electronics/computer-technology, in the writing of the RHINO XR Laboratory Manual Student Workbook. Much of their work involved designing lab activities and units to be implemented within the junior or senior high school.

Among their accomplishments, has been the conceptualization, design, and construction of a portable robotics workcell. This workcell was designed and programmed to produce a usable die (as in dice) from a two-inch wooden cube. The workcell was first exhibited before the public at the 1984 American Industrial Arts Association International Conference, Columbus, Ohio.

COURSE TITLE

"Exploring Industry and Technology"

(Level I - Elementary) Grades K-5

ROBOTICS APPLICATIONS

Introduction to Robots

1. Invite a person from a local high school or college who is associated with robotics to bring in and demonstrate an educational robot to your class.

(Examples: Hero 1, Armatron, Microbot, Topo, Rhino, Itsabot)

2. Compare and contrast robots with "Transformers" and "Gobots." Have students bring in their own transformers and gobots.
(ROBO Magazine is directed at this age level)

3. Discuss what robots are currently being used for?

a. material handling
b. welding
c. part assembly
d. painting

4. Discuss where are robots found?

a. industry
b. schools/colleges

5. Discuss what robots will be like in the future? Relate current science-fiction movies (Star Wars, Star-Trek) and the uses that they have portraited for robots. Bring in magazines such as Popular Science, Omni etc. and show students pictures of future uses of robots. Discuss what robots might be like in the home in terms of performing household operations.

COURSE TITLE

"Introduction to Industrial and Technological Systems" 18 weeks

(Level II - All Schools) Grades 6-7

ROBOTICS APPLICATIONS

Communication Systems

1. Use a robot and microprocessor to illustrate concepts of "person to machine" and "machine to machine" communication.

2. Develop skills in programing by writing programs that control a robot.

3. Challenge students to write the most "efficient" computer program directing a robot to accomplish some task.

Construction Systems

1. Plan, design & build a model of an automated commercial facility that uses robots for manufacturing and warehousing.

2. Design and construct a model of a safe robotics workcell.

3. Study the impacts of retrofitting existing plants within the comommunity incorporating robots.

Manufacturing Systems

1. Design a robotics workcell that takes several parts from different locations and places them into one package.

2. Design a transfer point where a robot moves a product from one point in an assembly or process to another.

Transportation

1. Design a transportation system using automation or robots to move materials.

2. Design a robot to mine the surface of the moon.

3. Design a robot to explore the ocean depths.

COURSE TITLE

"Communication Systems" 18 Weeks

(Level III - All Schools) Grades 8-12

ROBOTICS APPLICATIONS

Classification of Communication Systems

Electronic communication

1. Demonstrate electronic communication via computer and robot.

Light communication

1. Demonstrate light control mechanisms using optically encoded servo-motors on Rhino XR robot.

Hard-Wired Systems

1. Demonstrate control of a robot via the RS-232 cable.

Computer Systems

1. Demonstrate how a microcomuter may be used to control external devices such as the robot.

COURSE TITLE

"Electronic Communication Systems" 18 weeks

(Level IV - Medium and Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Hard-wired Systems

1. Demonstrate hard-wire interface of computer to robot via the RS-232 cable.

2. Demonstrate the same principle using the teach pendant and RS-232 cable

3. Demonstrate the principles of "human to machine" and "machine to machine" communication by writing programs to control a robot.

Light Communication Systems

1. Demonstrate the principles of light communication and feedback using the Rhino XR robot's optical encoding servo-motors.

Acoustic Communication Systems

1. Use a HERO robot to demonstrate ultrasonic communication systems.

2. Program a HERO robot to acoustically respond to the presence of someone within two feet of the ultrasnic sonar system.

Electronic Communication Products

1. Design an electronic robot that serves as a domestic servant that can be programmed for a variety of household functions.

2. Design a robot that will seek out and detect intruders.

3. Design a robot that will disarm bombs or explosives.

Trends in Electronic Communication

1. Discuss how computers and robots will change the nature of life in the future. Will computers and robots change the home, the workplace and the quality of life.

2. Discuss the role electronics has had in the development of both the computer and the robot.

COURSE TITLE

"Construction Systems" 18 Weeks

(Level III - All Schools) Grades 8-12

ROBOTICS APPLICATIONS

Research and development

1. Research the feasibility of constructing a robot maintained or serviced structure.

2. Research the feasibility of using robots on-site to erect commercial structures, roadways, or pipelines.

3. Determine the feasibility of using robots to manufacture modular homes.

Building the structure

1. Construct a model of the foundation for a robotic workcell to be included into a larger structure.

Installing Utility systems

1. Design a floorplan that shows the layout of a number of robots and all necessary utilities.

COURSE TITLE

"Electro/Mechanical Systems and Servicing" 18 weeks

(Level IV - Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Basic Theory of Mechanical Systems

1. Outline mechanical systems required to operate most industrial robots.

2. Design a work cell for some robotic application where the environment would be hazardous to humans.

3. Draw the layout of all mechanical systems needed for a robotic factory.

Ventilation and Pollution Control Devices

1. Design a ventilation system and pollution control devices for drawing smoke or particulate matter away from a robotics work cell.

2. Design a working environment which permits humans to monitor robots in a polluted or dangerous environment while being protected from pollutants or irritants.

Other mechanical Systems

1. Design a floor-mounted conveyor system that moves material from one robotic work cell to another.

2. Design a ceiling-mounted conveyor system that moves material from one robotic work cell to another.

3. Design a structure to be maintained by robots. Design the robots to clean floors, empty the garbage, and mow the lawn.

COURSE TITLE

"Construction Planning and Design" 18 weeks

(Level IV - Medium and Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Research and Development Process

1. Contact architectural firms and request information on designing and building for robotics applications.

2. Conduct a feasibility study to determine the cost/benefits of building a structure for robotic production versus labor intensive production.

3. Design a building which combines robotic work cells and human space into an integrated and harmonious work environment.

Engineering

1. Complete design drawings and a model of a robotics facility for a specific application.

2. Gather information on a number of industrial robots and determine which is most appropriate for a given structure and application.

COURSE TITLE

"Constructing and Servicing Structures and Systems" 18 weeks

(Level IV - Small and Medium Schools) Grades 9-12

ROBOTICS APPLICATIONS

Building the Stucture

1. Design floorplans for construction of a manufacturing facility using robots.

2. Conduct research into special considerations which must be accounted for when constructing structures which house robots in some work environment.

Introduce Mechanical and Electrical Systems

1. Conduct research into the utilities and services (heating, ventilation, electrical, hydraulic, etc) necessary for production facilities which house robots.

2. Design transportation or feed systems into a facility that supply materials to a series of robots.

3. Design a central location from where all robotic processes in a facility may be monitored and controlled.

Servicing the Project

1. Determine a schedule for installing and maintaining robots within a production facility.

2. Design a universal facility housing robots that may be altered or changed to produce one product or another as the need or market dictates.

COURSE TITLE

"Manufacturing Systems" 18 weeks

(Level III - All Schools) Grades 8-12

ROBOTICS APPLICATIONS

Introduction to manufacturing

1. Study the impacts of automation on American society.

2. Outline the major uses of industrial robots and decide whether they have helped or hurt mankind.

Managed Activities

1. Design a product to be manufactured totally by robots.

2. Develop a storyboard showing the sequence of steps necessary to complete this product using the robot.

3. Write a program to manufacture the product from the storyboard.

Evolution of Manufacturing

1. Discuss the growing importance of robotics in manufacturing.

2. Have students predict what the workplace will be like in ten years. Discuss the role of the worker in the automated workplace.

3. Discuss the social impacts of robots on employment and the quality of life.

COURSE TITLE

"Manufacturing Materials and Processes" 18 Weeks

(Level IV - All Schools) Grades 9-12

ROBOTICS APPLICATIONS

Primary Processing

1. Thermal Processing
2. Chemical Processing
3. Mechanical Processing

(Dirty, Dangerous & Dreary) - Show a film on these three areas and relate the 3-D's to the use of robots.

Transforming Standard Stock into Products

Casting and Molding

1. Discuss how robots are used to extract castings from molds (metals/plastics) and how robots prepare molds for casting in the fiberglass industry.

Forming

1. Discuss how robots could be used in loading and unloading forming machines.

Separating

1. Discuss the different "end of arm" tooling that robots use for separating materials (cutting torch, cutter bits, laser).

Conditioning

1. Discuss how robots are used in terms of heat treating metal.

Assembling

1. Show a film related to the use of robots in the automotive or electronics industry.

2. Discuss the different applications of robots that appeared in the film.

Finishing

1. Show film on the use of robots for spray painting in the automotive industry.

COURSE TITLE

"Product and Production System Design" 18 Weeks

(Level IV - Medium schools) Grades 9-12

ROBOTICS APPLICATIONS

Introduction to Product Design and Production Systems

System Elements

Research & Development

Production

System Components

Product Design System

Foundations of Design

Identifying and Defining Design Problem

Determining the Problem

Gathering the Information

Determine Design Approach

Defining the Problem

Developing Product Ideas

Visualizing Preliminary Product Ideas

Refining Product Ideas and Sketches

Communicating Product Ideas

Evaluating Product Ideas

Engineering and Specifying Products

Product Engineering

Specifying Product Characteristics

Testing Product Performance

Establishing Production Methods

Selecting Operations

Sequencing Operations

1. Using a developed product from the product design phase of the class, have the students individually or in groups decide if any of the operations can be performed by a robot.

2. Develop a methods sheet for the particular robot workstation(s).

3. Develop a mock-up of the robot workstation using sketches, drawings and have students brainstorm toward improving the design.

Engineer the Production Facilities

Selecting a Layout System

1. Have groups of students work together in determining space needs for the robot work station (workcell).

2. Have groups of students work together in planning a plant layout taking into consideration the placement of the robot workcell. Also, include a system for material handling involving the robot workcell.

3. Have each group present their plant layout plan to the class.

4. Select the best plan.

Determine Space Needs

1. Relate this to "Selecting a Layout System."

Allocate Space

Engineer a Material Handling System

Design and Fabricate Tooling

Determine the Tooling Needs

1. Have students assigned to the robot workcell station determine necessary tooling requirements.

Develop Possible Tooling Solutions

1. Have students brainstorm and sketch possible "end of arm" tooling ideas.

Select the Best Solutions

1. Have students discuss their ideas with each other and select the most feasible solution.

Prepare Tooling Drawings

1. Prepare final drawings for "end of arm" tooling.

Fabricate, Install and Test Tooling

1. Have students involved with the workcell build, install and test the "end of arm" tooling. Make modifications to design if unforeseen problems occur.

2. The robot workcell team after completing the design and fabrication process could then visit other classes (examples: science, math, social studies etc.) to discuss the entire process involved with creating a workcell. Also discuss the use of robot workcells in industry.

3. Invite a local T.V. station, newspaper crew to interview the students in the class involved with the workcell to promote the students efforts.

4. Have students invite parents to class or to parents night at school and demonstrate the materials covered in class.

5. Have students video-tape the process of creating a workcell for future reference in upcoming classes.

6. Show video-tape of students' activities during lunch time in the teachers lounge. Purpose: to let teachers know what is going on in your classroom and to build a working relationship with other areas.

Develop an Inspection System

Determine Inspection Needs

1. Have students determine inspection needs before and after materials reach the robot workcell.

Select Inspection Techniques

Develop an Inspection Reporting System

Schedule Manufacturing Activities

Operate The Production System

Train Workers

Produce Products

Inspect Inputs and Outputs

Supervise Workers

Monitor Production Activities

COURSE TITLE

"Manufacturing Production Systems" 18 Weeks

(Level IV - Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Introduction to Production Systems

System Components

System Elements

1. Relate the position of robotics engineer within an industrial organization using a previous class enterprise activity.

2. Relate the same position on an industrial organization chart obtained from a company that incorporates robotics within their production operations.

System Types

1. Discuss the feasiblity (cost/time) of using robots in industries that use:

a. custom production
b. job-lot/batch production
c. [illegible]inuous production

2. Sho[illegible] a film that demonstrates the various production uses of robots in industry

3. Tour a facility in your local area that has incorporated robotics into their production process.

Establishing Production Methods

Selecting Operations

Sequencing Operations

1. Using a developed product from the product design phase of the class, and have the students individually or in groups decide if any of the operations can be performed by a robot.

2. Develop a methods sheet for the particular robot workstation(s).

3. Develop a mock-up of the robot workstation using sketches, drawings and have students brainstorm toward improving the design.

Engineering Production Facilities

Selecting a Layout System

1. Have groups of students work together in determining space needs for the robot work station (workcell).

2. Have groups of students work together in planning a plant layout taking into consideration the placement of the robot workcell. Also, include a system for material handling involving the robot workcell.

3. Have each group present their plant layout plan to the class.

4. Have the class select the most feasible plan.

Determine Space Needs

1. Relate this to "Selecting a Layout System."

Allocating Space

Designing and Installing Handling Systems

1. Show a film of an automated plant incorporating state-of-the-art material handling systems.

2. Relate the film to class operations presently under consideration.

3. Have the class work in groups to plan and design a material handling system for the class.

Fabricating and Installing Material Handling Systems

1. Have a group of students fabricate and install the material handling system according to the plans.

Designing and Fabricating Tooling

Types of Tooling

Part Clamping Devices

1. Relate clamping devices used in industry (via magazines, films) for robotics workcells.

Designing Tooling

1. Have students assigned to the robot workcell station determine necessary tooling requirements.

2. Have the students discuss their ideas with each other and select the most feasible solution.

3. Prepare final drawings for "end of arm" tooling.

4. Have students involved with the robot workcell build, install and test the "end of arm" tooling. Make modifications to design if unforeseen problems occur.

5. The robot workcell team after completing the design and fabrication process could then visit other classes (examples: science, math, social studies etc.) to discuss the entire process involved with creating a robot workcell. Also, discuss the uses of robot workcells in industry.

6. Invite a local T.V. station, newspaper crew to to interview the class and their work with the workcell to promote the students' efforts.

7. Have students invite parents to class or to parents night at school and demonstrate the materials covered in class.

8. Have students video-tape the process of creating the workcell for future reference in upcoming classes. Create a video-tape library.

9. Show a video-tape of student activities during lunch time in the teachers lounge. Purpose: to inform teachers of what is going on in your classroom to build a working relationship with other areas in your school.

Develop a Quality Control System

System Elements

Determining Quality Standards

Selecting Inspection Techniques

Developing an Inspection Reporting System

Scheduling Manufacturing Activities

- Master Schedule
- Daily Production
- Work Orders
- Production Reports

Operate a Manufacturing System

- Train Workers
- Produce Products
- Inspect Outputs and Inputs
- Supervise Workers
- Monitor Production Activities

COURSE TITLE

"Transportation Systems" 18 weeks

(Level III - All Schools) Grades 8-12

ROBOTICS APPLICATIONS

Managing Transportation Systems

1. Design a material moving system that incorporates a robot.

2. Design a people moving system incorporating robots.

Marine Transportation

1. Design a robot to explore the ocean floor for minerals or oil.

2. Design a robot that would salvage submerged objects.

Heavier-Than-Air Systems

1. Design a robotic aircraft that would survey land masses or track weather.

Spatial

1. Design a robot to mine the surface of the moon.

2. Design a robot to repair space structures.

COURSE TITLE

"Technical Elements of Transportation" 18 Weeks

(Level IV - All-Schools) Grades 9-12

ROBOTICS APPLICATIONS

Propulsion Systems

1. Have students calculate the amount of horsepower needed for an educational robot to move a 3 pound object a distance of 3 feet.

Energy Converters

1. Have students examine an electric stepper motor found on an educational robot such as the Rhino XR Series.

Drive Systems

1. Examine the mechanical systems (gear, pulley) on an educational robot.

2. Relate the use of hydraulic systems used on industrial robots.

Control Systems

Suspension Systems

1. Have students examine the suspension systems of educational robots such as the Rhino Scorpian, TOPO, and Heathkit HERO-1.

2. Have students examine the guidance mechanisms of the same educational robots. Discuss how the particular systems work.

3. Discuss the use of a microprocessor and its use in guiding the robot.

Structure Systems

1. Have students build vehicle mock-ups for a particular robot design of their own choosing, taking into consideration the use of a guideway structure as well as problems they will encounter in terms of material handling, modes of transport and designs of terminals.

2. Have the students individually, or in groups discuss their robot mock-ups with the class.

Support Systems

1. Discuss with students the need for people to service robots in industry.

COURSE TITLE

"Planning and Designing Transportation Systems" 18 Weeks

(Level IV - Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Transportation: A Human Endevor

Classification of Transportation Systems

Urban Transportation Planning Parameters

Functional System Classifications

Transportation System Operations and Maintenance

Urban Transportation Environment

1. Have students brainstorm using hi-tech magazine sources on how robots might be adapted in terms of the transportation environment.

2. Discuss the ideas in terms of direct and indirect problems.

Modeling of Transportation Systems

1. Using ideas that students have assembled, have the students plan a transportation routing system using a map of the local community or nearby city. Take into consideration concentrations of people, land useage and future employment opportunities.

Distribution of Materials and Products

1. Have students design a future automated transportation system to be retrofitted to an existing railway and structures in the local community.

Functional System Classifications

1. Relate classification factors to previous activities.

International Transportation Systems

1. Discuss the "Space Shuttle" in terms of its automated

systems and how it may be used as an international transportation system for retrieval of satellites from space and landing/re-launching from various countries.

2. Have students design and build mock-ups of ships with automated storage retrieval systems and automated docking facilities.

Transport: Governmental Organization

Transportation and the Future

1. Have students brainstorm and discuss how robots will be interfaced with transporation systems of the future. Refer page 161!

COURSE TITLE

"Human and Product Transporting Systems" 18 Weeks

(Level IV - Medium and Large Schools) Grades 9-12

ROBOTICS APPLICATIONS

Transportation--Routes in Conjunction with Mode, Medium & Commodity

Transportation for Place Utility

1. Have the students obtain a set of architectural plans of an existing industry within the community or a nearby community that already incorporates robots. Study the operation and economic factors involved with automated transportation systems within the facility.

Transportation Safety and Ecological Factors

1. Discuss the pros and cons of automated control within a plant in terms of the type of production used.

Transportation Vehicle Considerations

1. Show a film that presents various automated vehicle transporation systems.

2. Discuss the various guidance systems used in these settings.

COURSE TITLE

"Research and Development" 18 Weeks

(Synthesis Level -- All Schools) Grades 10-12

ROBOTICS APPLICATIONS

Research and Development as a Process

Research and Development as a Concept

1. Select a technical research and experimentation problem such as:

a. determining the feasiblity of designing, building and testing a scale model of an automated mobile railroad track repair unit incorporating the Rhino XR robot.

b. designing, building, and testing a robotics workcell that simulates a spray painting booth using a robot and an airbrush. Program the robot to paint small parts that pass by it on a conveyor system.

c. using a dremel tool attached to the end of a robot arm that serves as a deburring tool. Design a workcell that deburrs wax castings.

d. a technical problem that has arisen in the enterprise class at Level V related to robotics. Use the scientific approach to solve the problem.

Process to Developing

1. Have the students submit a research proposal to the teacher for approval. Upon approval of plan, then develop a contract binding the student to their proposal for solving a technical problem in robotics or industrial automation.

COURSE TITLE

"The Enterprise" 18 Weeks

(Synthesis Level -- All Schools) Grades 10-12

ROBOTICS APLLICATIONS

Review Basic Content of the Four Systems

Review the Basic Concept of the Enterprise System

Form a Company

1. In creating a company, include a position in the organizational pattern for a robotics engineer(s).

Activate the Company

1. Write a job classification and description for the position of robotics engineer.

2. Have the company state in its policy manual, the intent of the company to incorporate robotics into its production planning scheme.

Industrial Relations

1. Interview students applying for the position of robotics engineer.

Operating the Enterprise

1. Incorporate the use of a robot(s) into manufacturing processes, procedures and schedules of the company. (Example: methods sheets, flow process sheets, master schedule etc.).

Production/Goods/Services

1. Determine tooling needs for robotics operations.

2. Design, fabricate, and test tooling.

3. Incorporate robots in the material handling system (Example: near conveyor belts, bins etc.).

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